



CMOS Lens Selection and Suppliers

The purpose of a lens is to collect and focus photons of light. Imaging lenses are classified by format, mounting, focal length, f-number, and other parameters.

Lens Format

A lens' format is a specification of the size of the image that the lens can produce. The measurement of a lens' format is related to the diagonal size of the intended image sensor. This relationship is loose, however, and can mislead. As examples, a 1/2-inch format lens is for use with a sensor having an 8.0-mm diagonal, not a 12.7-mm diagonal, and a 1/4-inch format lens is for use with a sensor having a 4.0-mm diagonal, not a 6.35-mm diagonal. This table relates image sensor optical formats (and the corresponding lens formats) to actual sensor diagonals.

Optical Format	Actual Sensor Diagonal
1/6 inch	~2.7 mm
1/4 inch	~4 mm
1/3.2 inch	~5.7 mm
1/3 inch	~6 mm
1/2.5 inch	~7.2 mm
1/2 inch	~8 mm
1 inch	~20 mm

Mounting

The lens typically is designed to mount into a standard fixture that surrounds the sensor, and there are several standards. In CMOS camera systems, C-mount, CS-mount, and S-mount are common mounting thread formats. S-mount works well in designing small cameras, but the small S-mount lenses are often inferior to their C-mount equivalents, and image quality suffers.

Mount	Threads	
C	132	Back flange-to-image distance = 17.526 mm, common in CCTV
CS	132	Back flange-to-image distance = 12.5 mm, sometimes in CCTV
S	M12 x 0.5	Common in PC cameras and board-mount systems

Focal Length

This parameter indicates how far behind the principal plane of a lens an image will form, as well as the magnification obtained from the lens for a given imaging condition. A lens with a long focal length produces images far behind the lens' principal plane, as well as high magnifications and narrow fields of view (like a telephoto lens). A lens with a short focal length produces images close behind the lens' principal plane, as well as low magnifications and wide fields of view (like a wide-angle lens).

For typical imaging systems, the horizontal field of view is 35 to 45 degrees. For most applications, the relationship between a lens' focal length, f , an image sensor's width, w , and the lens/sensor combination's field of view, θ , is equated as:

$$\theta \approx 2 \tan^{-1} \left(\frac{w}{2f} \right)$$

Eq. Field of View

where \tan^{-1} is the trigonometric operation arc-tangent. In this equation, if w is the image sensor's horizontal width, then θ is the camera system's horizontal field of view. Alternatively, if w is the image sensor's diagonal width, then θ is the camera system's diagonal field of view.

F-Number

This is the "focal ratio," the ratio of the lens' focal length to its diameter (or aperture). It usually ranges from $f/1.4$ to $f/8$. Smaller f-numbers let in more light, while larger f-numbers allow more latitude for focus. The amount of light let in by the lens is inversely proportionate to the square of the f-number. This means that an $f/8$ lens lets in 16x less light than an $f/2$ lens. The iris of some lenses provides control over the f-number or effective lens diameter. In low-cost applications, however, the f-number is usually fixed and it is preferable to have an $f/1.4$ or $f/2$ lens so that the sensor receives as much light as possible.

Choosing the Right Lens

An imaging lens is needed to provide the sensor with an accurate representation of the object to be captured. As in conventional photography, but with the sensor replacing film, the lens fits between the sensor and the object. Light from the object passes through the lens, and the lens forms an image of the object where the sensor is located.

To match the sensor's image-detecting ability to the lens' image-forming ability, the size, number, and distribution of the sensor's pixels must be compared to similar quantities in the lens' image. In determining when such a match is optimal, two parameters must be considered: the size of the sensor's pixels ("resolution") and the overall size of the image sensing array ("format").

RESOLUTION—If a particular image sensor contains pixels that are, for example, 5 microns wide, then the proper lens to use with that sensor should be able to resolve 5-micron-wide features in the images it forms. If the lens used cannot resolve image features as small as 5 microns, then the images resulting from that

particular lens/sensor combination will appear to be blurry. On the other hand, if the lens used resolves image features that are equal to, or smaller than, 5 microns wide, then the resulting images will be sharp. This principle can be taken too far, however, when the lens used can resolve image features that are much smaller than the sensor's pixel size.

FORMAT—If a particular sensor array has a 1/4-inch optical format (corresponding to a diagonal of approximately 4 mm), for example, then the proper lens to use with it will be one that can form images at least as large as a 1/4-inch format (but not much larger). Use of a lens having this ability will produce images that are filled out to the corners, while use of a lens that cannot form images of sufficient size will result in images with the corners cut off.

Beyond resolution and format, there are other parameters to consider when choosing optics for electronic imaging. "Distortion," for one, is a measure of the degree to which lines that should be straight appear bent or curved in the image formed by a lens. The parameter of "relative illumination" describes the brightness of the corners of a picture, relative to the brightness of its center. The "f-number," as noted, describes how much light gets through a lens to form an image on the sensor. And the parameter of "field of view" describes how wide of an image, in degrees, a particular lens/sensor combination will capture. These parameters are often interdependent.

CMOS Imaging Lens Suppliers

This list of lens suppliers includes companies that our customers have worked with in the past. Micron does not endorse or specifically recommend any one lens supplier, though the list may serve as a starting place for finding a supplier that best meets your needs and a product that works in your system.

Lens Company Name	Website
Catalog Lens Suppliers	
Marshall Electronics	http://www.mars-cam.com/optical.html
Navitar	http://www.navitar.com/
Mass Production Lens Suppliers	
AOET	http://www.toplens.com.tw
Copal	http://www.nidec-copal.com/
E-Pin Optical Industry Co., Ltd.	http://www.epin.com.tw/html/english/
Konica Minolta	http://konicaminolta.com/index.html
Largan	United States: http://www.largan.com Taiwan: http://www.largan.com.tw
MaxEmil	http://www.maxemil.com.tw
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